



NEUTRON REPULSION - POWERS BEYOND THE DREAMS OF SCIENTIFIC FICTION

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ABSTRACT

The purpose of this review is to share experimental evidence of neutron repulsion with others - and to show graphically why elusive neutron repulsion was overlooked as the likely source of "powers beyond the dreams of scientific fiction" in the development of nuclear energy - before neutron repulsion is presented for public discussion at the London GeoEthics Conference on Climate Change on September 8-9, 2016. Aston first suggested atomic "powers beyond the dreams of scientific fiction" in the last paragraph of his 1922 Nobel Lecture, ten years before the neutron was discovered in 1932. Aston's expression of nuclear "packing fraction" was largely replaced in nuclear science textbooks after 1935 by the cunning concept of nuclear "binding energy," based on the neutron-proton model of the atomic nucleus. When Aston repeated his Nobel Lecture at the Imperial University of Tokyo in 1936, a talented 19-year-old student apparently recognized the discrepancy between measured "packing fraction" and calculated "binding energy." Soon after neutron-induced fission of uranium was first reported in early 1939, other scientists independently reported numbers of secondary neutrons released during fission that might induce a self-sustaining chain of nuclear reactions. This became the basis for nuclear secrets and atomic bomb production during WWII. Three-dimensional plots of precise atomic rest mass data from Brookhaven National Laboratory revealed neutron repulsion as a powerful, short-range nuclear force in 2000. Neutron repulsion was later identified as the trigger for neutron-emission from pulsar cores of ordinary stars, like the Sun, and the primary source of solar energy.

KEYWORDS: Energy, Nuclear, Astronomy, Space, Repulsion, Fission.

1. Introduction

Einstein (1905) reported mass (m) is stored energy (E) before it was known that atoms of the same element may have different atomic masses. Aston used the mass spectrograph to identify isotopes of several elements, measured and reported their masses as nuclear "packing fractions," and reported that these offer the human race command over "*powers beyond the dreams of scientific fiction*" in the last paragraph of his Nobel Lecture (Aston, 1922). Chadwick (1932) later discovered the neutron and described it as "a proton and an electron in close combination," thus explaining why Aston observed only whole integer values of atomic mass numbers. Weizsäcker (1935) developed the concept of nuclear "binding energy" based on the neutron-proton model of the nucleus. Bethe and Bacher (1936) also used the neutron-proton model of the nucleus to explain stationary states of nuclei. When Aston repeated his 1922 Nobel Lecture at the Imperial University of Tokyo in 13 June 1936, Kuroda (1992) noticed and commented on an apparent misunderstanding of nuclear "packing fraction" that will be illustrated here in the neutron-proton model of nuclear "binding energy." After neutron-induced fission of uranium was discovered (Hahn and Strassman, 1939), other scientists independently discovered and reported the number of secondary neutrons released and the possibility of neutron-induced self-sustaining chain of nuclear reactions in 1939 (Anderson et al., 1939; Hagiwara, 1939; Halban et al., 1939; Zinn and Szilard, 1939). Bohr and Wheeler (1939) used the neutron-proton model of the nucleus in proposing a mechanism for nuclear fission.

2. Materials and Methods:

The materials and methods are essentially the same as those used in the paper published earlier this year on solar energy (Manuel, 2016): Precise atomic rest mass data from the National Nuclear Data Center, Brookhaven National Laboratory are used to identify neutron repulsion as a source of energy in atoms and to explain why this source of energy was overlooked in the historical development of nuclear energy.

3. Results:

The first figure shows the rest masses of atoms as they might have appeared to Aston in 1922, before the neutron was discovered in 1932 and the neutron-proton model of the nucleus was proposed in 1935.

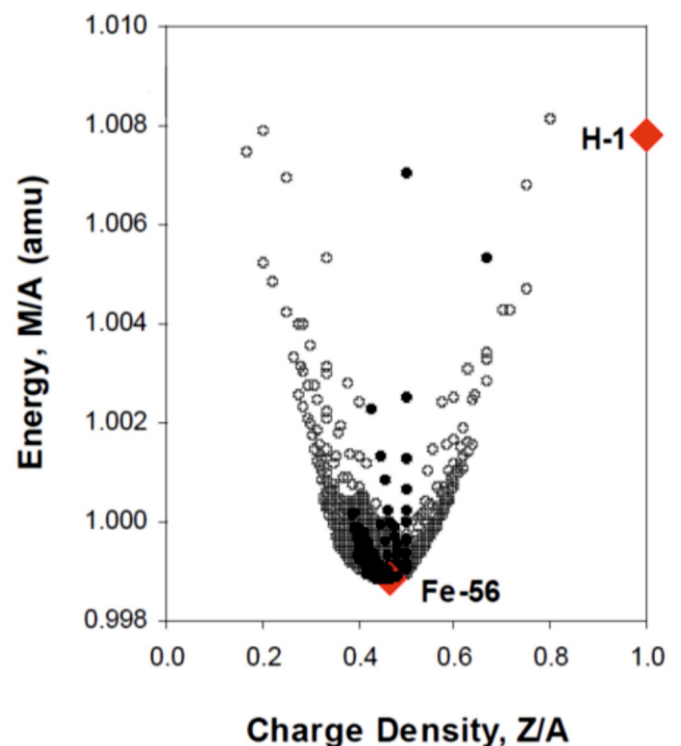


Figure 1. The horizontal scale is charge density. The vertical scale is mass (energy) per nucleon, or $1 + f$, where f = Aston's nuclear "*packing fraction*."

The second figure shows rest masses of atoms as they appeared to Weizsäcker and to several others after Chadwick (1932) discovered and reported the neutron.

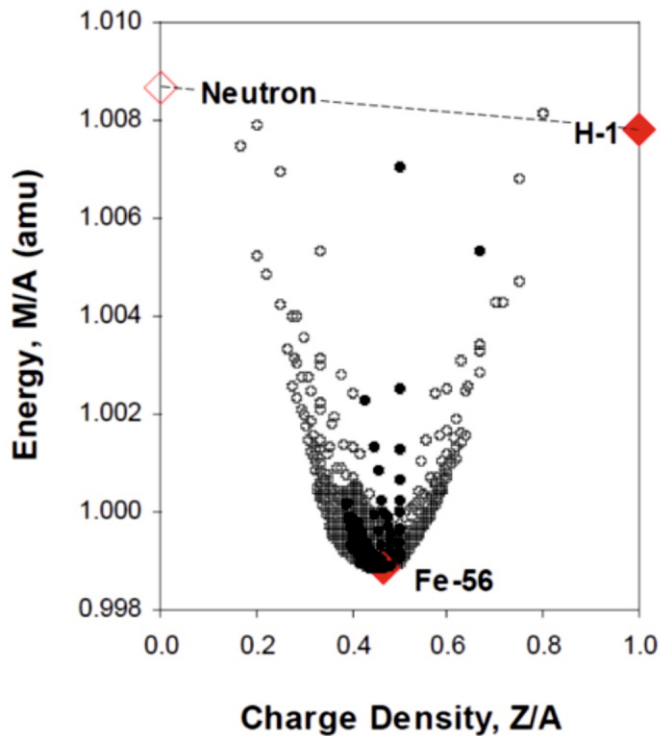


Figure 2. The horizontal scale is charge density. The vertical distance of atomic mass from the dashed line is Weizsäcker nuclear “binding energy” per nucleon.

The third figure shows least-squares fitted mass parabolas to rest mass data at each mass number, A , with intercepts at $Z/A = 0$ (blue) and 1 (red).

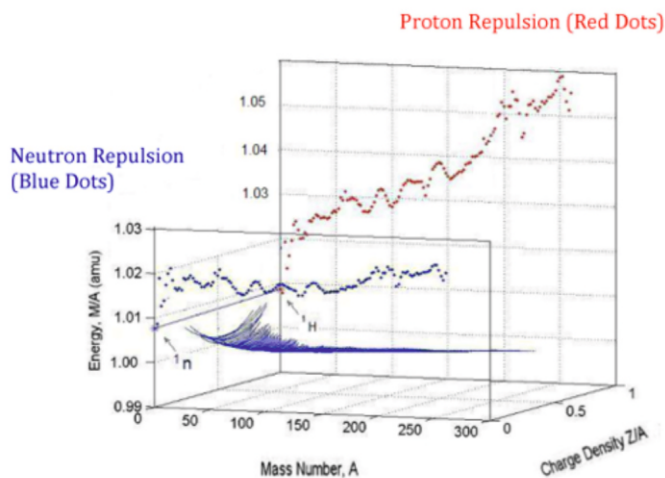


Figure 3. The red dots at $Z/A = 1$ show energy (mass) from proton repulsion and the blue dots at $Z/A = 0$ show energy (mass) from neutron repulsion.

The fourth figure shows why neutron repulsion is of interest to those studying global climate change.

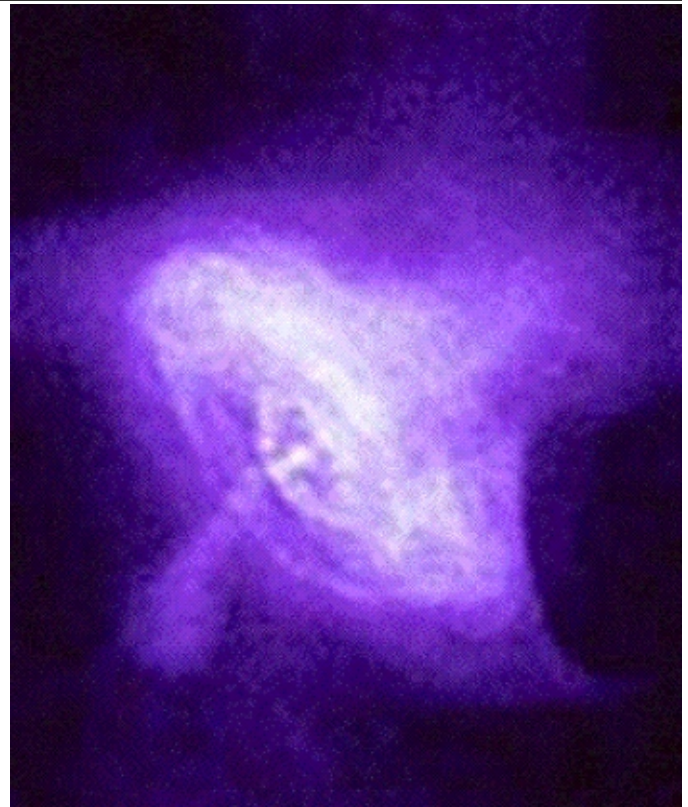


Figure 4. Neutron repulsion in the Sun's pulsar core causes eruptions and climate change (Carrington, 1859; Manuel et al. 2002; Karoff et al. 2016).

4. Discussion:

Experimentally measured atomic mass data points in Figures 1 and 2 are filled for stable atoms; open for radioactive atoms. These were used to define mass parabolas at each mass number (A) in Figure 3. The only experimentally measured atomic mass data points in Figure 3 are those of the neutron (${}^1_0\text{n}$) and the hydrogen atom (${}^1_1\text{H}$) at $A=1$.

Strong attractive forces between neutrons and protons produce low values of M/A in mass data points and in the mass parabolas near $Z/A \sim 0.5$ in these figures.

Blue dots in Figure 3 are values of M/A calculated from mass parabolas for hypothetical atoms composed of neutrons only at $Z/A = 0$. Neutron repulsion causes values of M/A (blue dots at $A > 3$) to be consistently higher than that of the free neutron at $A = 1$. Neutron repulsion is a strong, but short-range nuclear force (Manuel, 2016).

Red dots in Figure 3 are values of M/A calculated from mass parabolas for hypothetical atoms composed of hydrogen only at $Z/A = 1$. Proton repulsion causes values of M/A (red dots at $A > 1$) to be consistently higher than that of the hydrogen atom at $A = 1$. Proton repulsion is long-range, causing values of M/A at $Z/A = 1$ to increase with mass number, A (Manuel, 2016).

Neutron repulsion is relatively unimportant in light atoms when the nuclear core is neutron-proton pairs and extra neutrons are at the nuclear surface. Neutron repulsion becomes increasingly important above $A \sim 144$ amu, when Coulomb repulsion becomes strong enough to cause an inversion of the nuclear structure. Above $A \sim 144$ amu, the nuclear core is neutrons and the nuclear surface is neutron-proton pairs (Manuel, 2016).

To understand why neutron repulsion was overlooked as knowledge of nuclear energy developed, Figure 1 illustrates Aston's view of rest mass data (Aston, 1922) before Chadwick (1932) discovered the neutron. The decrease in values of M/A as the charge density (Z/A) decreased from 1 to 0.5 might be explained by a decrease in Coulomb repulsion between positive charges. But this could not explain the mysterious, unknown force that caused values of M/A to increase as the charge density (Z/A) decreased further, from 0.5 toward 0. Aston could not have identified that force as “neutron repulsion” in 1922. Aston (1922) probably identified that force as one that offered the human race command over “powers beyond the dreams of scientific fiction.”

To demonstrate further why neutron repulsion was overlooked in the development of nuclear energy, the dashed line in Figure 2 illustrates the subtle difference between nuclear “packing fraction” (Aston, 1922) - an experimentally measured thermodynamic state function - and nuclear “binding energy” (Weizsäcker, 1935) - a calculated thermo-dynamic path function. Weizsäcker's “binding energy” is represented in Figure 2 by the vertical distance down from the dashed

line to any mass data point. Because the neutron has greater mass than the hydrogen atom, this distance is deceptively high for neutron-rich atoms, and deceptively low for proton-rich atoms. That is why neutron-rich radioactive atoms like ^3H and ^{14}C have higher calculated values of nuclear “binding energy” than their stable decay products, ^3He and ^{14}N .

Weizsäcker's model of nuclear “binding energy” obscures neutron repulsion, exaggerates proton repulsion and illustrates Kuroda's concern when a physicist asked, “*What is meant by packing fraction?*” after Aston lectured on nuclear “packing fractions” at the Imperial University of Tokyo on 13 June 1936 (Kuroda, 1992).

5. Conclusions:

Neutron repulsion is a nuclear force that offers the human race command over “powers beyond the dreams of scientific fiction” (Aston, 1922). Neutron repulsion is of interest to scientists studying global climate change because most solar energy is produced by neutron repulsion in the Sun's pulsar core (Manuel, 2016) illustrated in Figure 4.

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